A Prototype of the sPHENIX Hadronic Calorimeter

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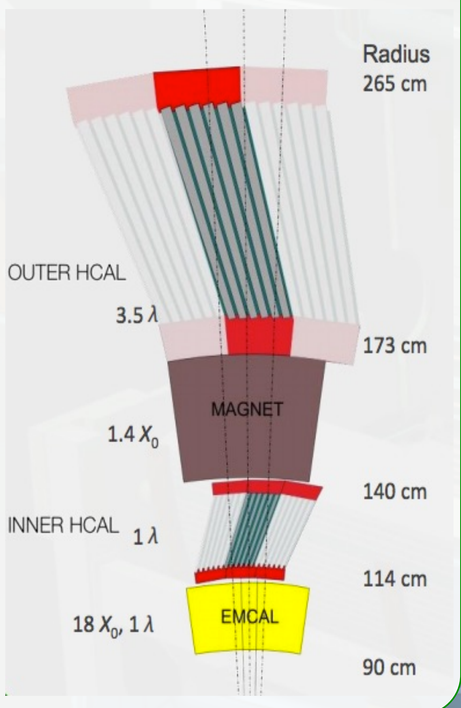
Abstract

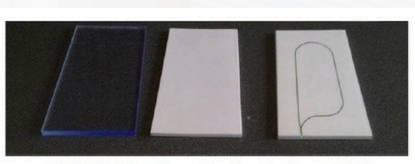
The proposed sPHENIX experiment is designed to reconstruct jets in heavy-ion collisions at RHIC. A crucial component to reconstructing the energy of jets is the sPHENIX calorimeter system which includes electromagnetic and hadronic calorimeters. The hadronic calorimeter (HCal) is a sampling calorimeter with alternating layers of steel absorber and scintillating tiles. There is an inner and larger outer HCal, located inside and outside of the sPHENIX solenoid. Prototypes of the EMCal, inner HCal and outer HCal were tested at the Fermilab Test Beam Facility. Measurements of the energy resolution satisfy the requirements of the proposed sPHENIX physics program and are consistent with GEANT4 simulations. This poster presents the design and performance of the HCal prototypes at the Fermilab test beam.

Design

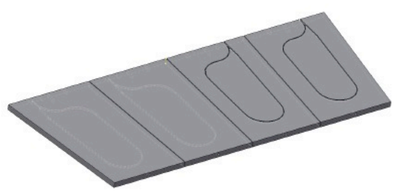
A cross-section of the sPHENIX calorimeter system is shown on the right. The inner HCal is situated inside of the solenoid magnet. The outer HCal is stationed outside of the solenoid magnet and additionally serves as the magnet flux return. The tilt angle 32 degrees (inner) and 12 degrees (outer) are chosen such that a straight track traverses 4 layers of scintillator and absorber. The calorimeter provides full azimuthal and -1.1<η<1.1 coverage. The individual HCal towers cover ΔΦ x Δη of approximately 0.1 x 0.1, for a total of 64 towers azimuthally and 24 towers in pseudorapidity for both inner and outer.



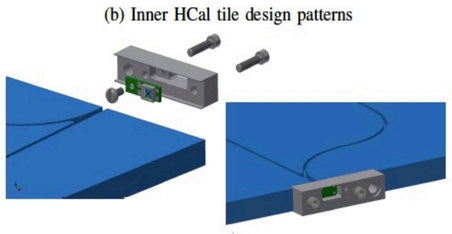
Prototype Construction



(a) Scintillator tile production for inner HCal



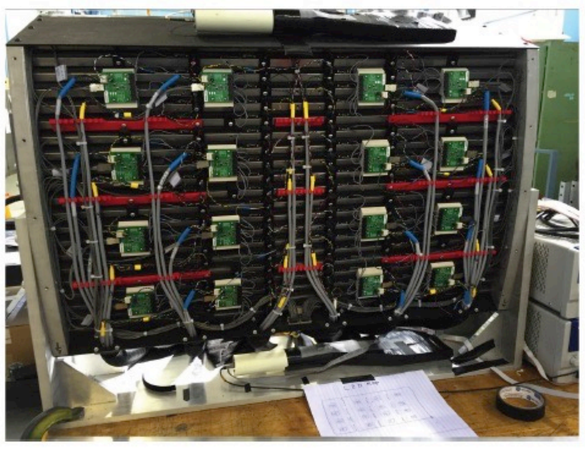
(b) Inner HCal tile design patterns



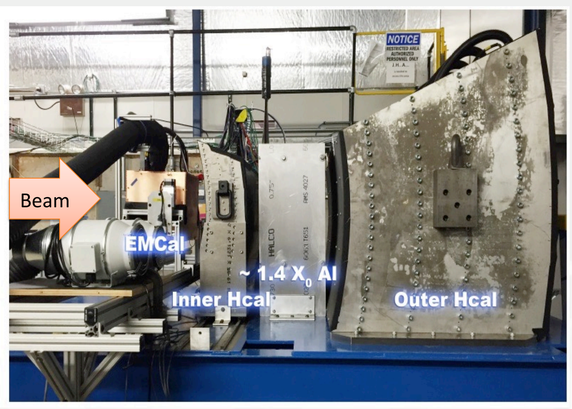
(c) Plastic coupler to attach the SiPM at the fiber exit

The inner and outer HCal prototypes are constructed with alternating layers of scintillator tiles and steel absorber plates. The absorber plates are tapered and tilted from the radial direction. Extruded tiles of plastic scintillator with an embedded wavelength shifting (WLS) fiber are interspersed between the absorber plates. HCal tile production steps are shown on right (a) tiles are being machined, coated and then embedded with WLS fiber. (b) 4 scintillating tiles arranged symmetrically to be inserted between the steel absorber plates. (c) SiPM installation at the fiber exit using a plastic coupler.

The tilt angle is chosen so that a radial track from the center of the interaction region traverses at least four scintillator tiles of each HCal. Fully assembled inner and outer HCal prototypes are shown below.

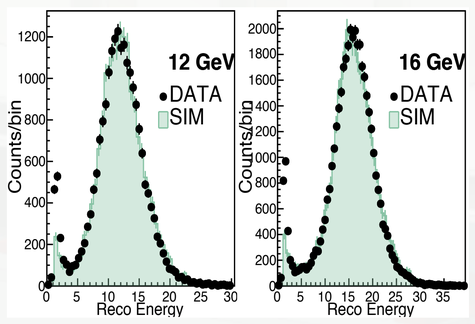


Fermilab Test Beam Setup



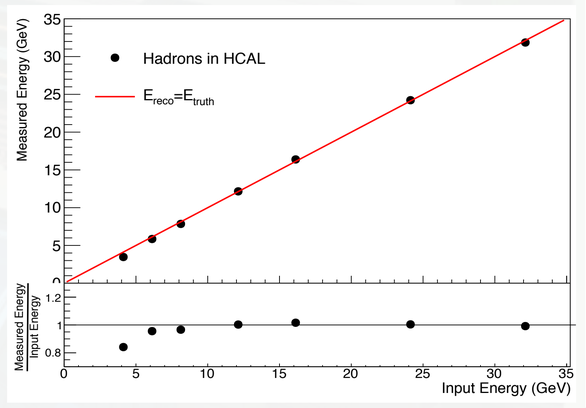
Testing of the prototype detectors was performed at the Fermilab Test Beam Facility (FTBF) designated as the T-1044 experiment. The setup is shown on the left. The beam goes from left to right interacting with the sPHENIX prototypes of EMCal, the inner HCal, a "mock cryostat" and the outer HCal.

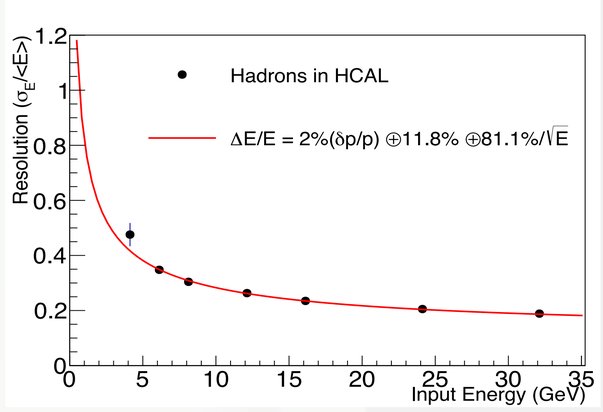
HCAL Standalone Measurements



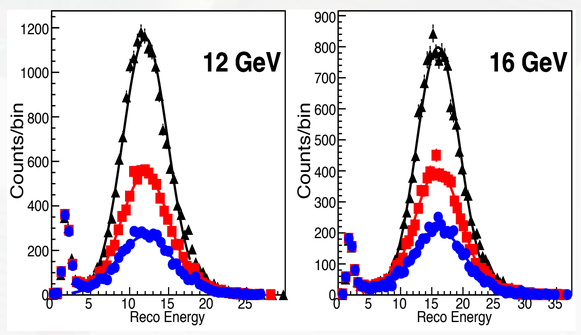
HCAL calibration was performed using cosmic muon events in order to equalize the response of each tower. Figure on the left shows hadron energy reconstruction at 12 and 16 GeV, along with the Geant4 simulation of the HCal.

The corresponding hadron linearity and resolution are shown below. A beam momentum spread of δp/p≈2% is unfolded in the resolution calculation.





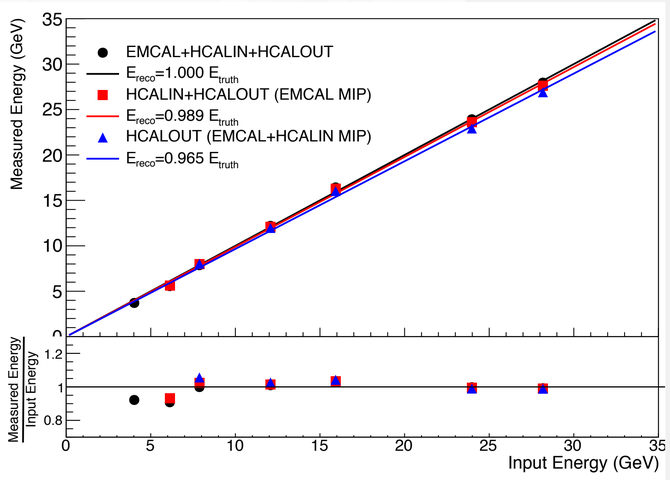
Full sPHENIX Calorimetry Measurements



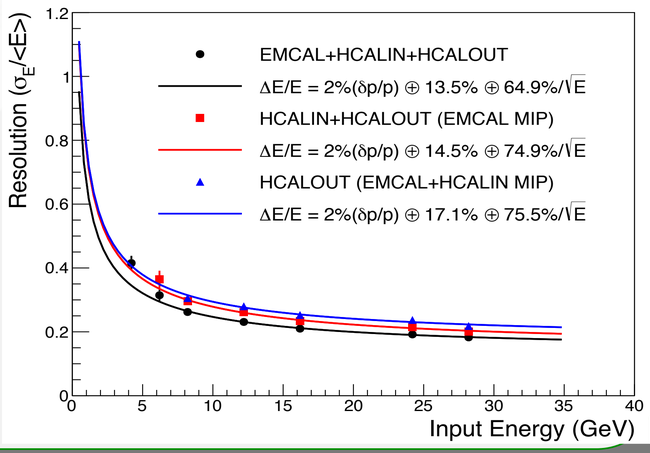
Hadron events are sorted into three categories depending on their longitudinal shower profile:

1. **HCALOUT**: MIP through inner HCAL and EMCAL.
2. **HCALIN+HCALOUT**: MIP through EMCAL.
3. **EMCAL+HCALIN+HCALOUT**: All events

The linearity is shown on the right. We normalize FULL reconstructed showers to the input energy. This resulted the HCALIN+HCALOUT and HCALOUT shower linearity slightly below the input energies due to higher leakage in those event categories.



Hadron resolution from three event categories are shown on right. The performance demonstrates the calorimetry design can achieve the sPHENIX specifiaction of better than 100%/√E energy resolution for single hadrons.



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